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# A PROGRESS REPORT ON INVESTIGATIONS OF INSECTS AFFECTING SUGAR BEETS GROWN FOR SEED IN ARIZONA AND NEW MEXICO

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## INTRODUCTION

A number of insect problems have arisen in connection with the production of sugar beet seed in the Southwestern States. The beet leafhopper has been recognized as a major pest of this crop for some time. The effect of this insect on sugar beets grown for seed and methods used for its control will be discussed in another publication. The present report concerns itself specifically with certain insects that attack sugar beet plants in the fruiting stage, attention being directed chiefly to those insects whose feeding punctures in seed balls reduce germination.

The first commercial plantings of sugar beets for seed were made in the Southwest on a small scale in the Mesilla Valley of New Mexico in 1927 and in the Salt River Valley of Arizona during the fall of 1934. Since 1935 large acreages have been grown in both New Mexico and Arizona. It was observed that the viability of the seed produced in either the Arizona or New Mexico areas was not always so high as might reasonably have been expected judging from the general vigor of the plants, and further, that strong fluctuations in viability occurred from year to year. Several kinds of plant bugs which were known to occur in the areas had been shown to damage alfalfa grown for seed 1/ and also to attack cotton plants.2/ While these insects had been noted to occur in the seed-beet fields, it was not known whether they were affecting the beet-seed crop adversely. Therefore, in

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1/ Stitt, Loyd L. Three Species of the Genus Lygus and Their Relation to Alfalfa Seed Production in Southern Arizona and California. U. S. Dept. Agr. Tech. Bul. No. 741, 19 pp. 1940.

2/ Cassidy, T. P., and Barber, T. C. Hemipterous Insects of Cotton in Arizona; Their Economic Importance and Control. Jour. Econ. Ent 32: 99-104. 1939.

1938, recognizing the possible importance of insects to this comparatively new industry, the Bureau of Entomology and Plant Quarantine readjusted its program of work on sugar beet insects to include a study of this problem. The headquarters of these investigations was located at Phoenix, Ariz.

These studies have had for their objective (1) the identification of those potentially economic insects found to occur in the seed-beet fields, (2) the determination of the effect, either on seed viability or yield, of the feeding of these insects on sugar beets grown for seed, and (3) the development of control measures which could be utilized against the insect pests found to be of economic importance. This report, which covers the period from April 1938 through the season of 1940, is issued for the purpose of supplying those interested with the information obtained on the problem since the studies were initiated. The control experiments are considered as preliminary tests, and any conclusions drawn from them may need to be modified as further data are accumulated.

## OCCURRENCE OF INSECTS IN THE BEET FIELDS

Studies of insect populations in fields of sugar beets grown for seed in the Salt River Valley of Arizona have been made by taking samples of the insect populations at regular intervals in fields selected as representative of the valley. In this work all insects of any possible economic concern or unusual abundance have been considered. In New Mexico, both in the Mesilla Valley and at Albuquerque, it has not been possible to carry on regular insect-population studies in the seed-beet fields, but samples have been taken in these fields as time would permit.

These studies showed that the tarnished plant bug, Lygus pratensis oblineatus (Say), and two closely related species, L. hesperus Knight and L. elisus Van Duzee, were present in every field, and that certain plant bugs commonly known as stinkbugs also occurred in most of the fields but in smaller numbers. Lygus spp. occurred throughout the entire fruiting stage of the beet plant, from the preblossom stage until seed maturity, while the stinkbugs, of which the most important is probably the large green stinkbug known as Say's stinkbug (Chlorochroa sayi Stal), occurred in very small numbers at the first of the season. Populations of this stinkbug increased slowly, so appreciable numbers did not occur in the fields until the crop was nearly mature. Under certain conditions, however, Say's stinkbug has been known to migrate to the sugar beet fields in large numbers during the fruiting stage of the plants. Under such conditions the numbers of this insect in the beet fields become exceedingly large, and great reductions in the percentage of viable seed produced have resulted. Such an outbreak of Say's stinkbug occurred in the beet fields of the Mesilla Valley, N. Mex., the latter part of May 1940.

The predominating species of Lygus occurring in the beet fields have been found to differ in the various beet-seed-producing districts of Arizona and New Mexico. In the Salt River Valley of Arizona Lygus hesperus and L. pratensis oblineatus predominate, in the Mesilla Valley of New Mexico

L. pratensis oblineatus and L. elisus predominate, while at Albuquerque, N. Mex., L. elisus is the predominant species. This variation in the occurrence of these three species of Lygus is important, because cage studies have shown that L. elisus is not so detrimental to beet seed as the other two species. In the Salt River Valley, where the more intensive studies have been carried on, a direct correlation has been found to exist between the numbers of Lygus adults and nymphs present on the seed stalks in May and the percentage of nonviable seed produced.

Based on three seasons' observations, the indications are that more or less damage can be expected from Lygus every year; in some years populations will undoubtedly be greater than in others and greater damage can be expected. These insects overwinter in the Salt River Valley largely on weeds, primarily mustard (Sisymbrium iris L.) and sowbane (Chenopodium murale L.), and breed on these weed hosts early in the spring. By mid-April adults become numerous and move from the weed hosts to the beets and other crops. This influx into the beets is practically completed late in April, at which time seed stalks are well developed in the beet fields, and by mid-May large numbers of nymphs appear on the developing seed. It is indicated, on the other hand, that Say's stinkbug may be of minor importance as a pest of beets grown for seed, except during outbreak years.

## CAGE STUDIES

The various species of potentially economic insects found to occur in the beet fields were caged separately on beet plants in the fruiting stage to determine the type and amount of damage attributable to each. In 1938 and 1939 studies were conducted in large cylindrical cloth-covered cages. These cages were of sufficient size to enclose the entire inflorescence of one sugar beet plant and were primarily for the purpose of determining the type, rather than the amount, of damage attributable to the various species of insects. A definite number of insects were placed in each cage and allowed to reproduce normally. In order to lessen the effect of the cage on the plant a material with as large meshes as would retain the insects was used. Curtain scrim having 16 meshes per linear inch was selected as a suitable material for the larger insects; for the smaller insects a cheesecloth with high thread count was used. The two types of cage covering were used in different experiments. In each experiment the cages were arranged in randomized blocks. The cages were placed on the plants as soon as the seed stalks appeared in the spring (April 11) and were left in the field until after the seed had matured (June 7). Figure 1 shows the isolation cages of 1939 in the field.

At harvest time the seed 3/ from each cage was harvested separately and analyzed to determine the quantity, both by weight and volume, and the

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3/ Sugar beet seed in commercial usage refers to the seed ball, which may contain one or more true seeds. In this circular the common usage of referring to the seed ball is followed.

quality of seed produced. The percentage of small unmarketable seed and the weight of seed per unit of volume, as well as the percentage of viable seed, were considered in determining the quality. The viability of the seed was determined in two ways, by actual germination and by the crack test. The germination tests were made by a recognized seed-testing laboratory, 400 seed balls constituting a sample. The crack test consisted of cracking the seed balls against a hard surface, the appearance of the starch being taken as an indication of viability, 300 seed balls constituting a sample. The studies of 1938 were more or less preliminary, and since these data corroborate those of 1939 the results from the experiments of 1938 are not given.

The cage studies of 1940 were somewhat more detailed than those of 1938 and 1939 and were designed to determine whether there were differences in the amount of damage caused by the three species of Lygus occurring in the Southwest, as well as the comparative damage caused by females, males, and nymphs. Comparative tests were also made with adults of Say's stinkbug. Cloth-covered cages, approximately 7 inches in diameter and 14 inches long, were attached to a section of the stalk, and one specimen of a species to be tested was placed in a cage. To prevent reproduction in the case of the females, reared unfertilized specimens were used. The cages were examined every 2 or 3 days, and any dead specimens were replaced. The nymphs were allowed to remain in the cages until they changed to adults, at which time each was replaced with another nymph.

These cages were placed on the plants in the very early blossom stage (May 1 to 10) and allowed to remain until seed maturity (June 19 to 24). Since the seed had not yet formed, a definite number of seed could not be enclosed in each cage, but a length of spikelet estimated to produce from 300 to 400 seed balls was enclosed within each cage.

Plants used for these tests were protected from outside infestation by large screen cages. One of these screen cages with the small sleeve cages inside is shown in figure 2.

The seed from each of these cages was analyzed to determine the amount of damage attributable to the various insects. The results of the tests of 1938 and 1939 had shown that the nature of the damage was a reduction in the viability of the seed rather than a reduction in yield, therefore the analysis of the seed from the cages of 1940 was designed to determine the amount rather than the type of damage attributable to these insects. For this reason all seed produced within a cage was germinated; and since the number of seeds produced per cage was far in excess of the number damaged by the insect, the number of nonviable seeds produced should approximate the number that the insect under observation is capable of damaging during the developmental period of the seed. The germination tests in this case consisted of a sprout count as well as a ball count in order to determine whether the insects were damaging all seeds within the ball or whether one or more seeds within a ball might be injured without damage to other seeds within the same ball. These germination tests were made by the writers. Preliminary tests of equipment and technique showed that results comparable

with those of the seed laboratory employed to make germination tests in 1938 and 1939 could be obtained.

## Experiment I, 1939

This experiment included those larger insects that could be retained in the curtain-scrim cages. These insects are listed in table 1, and data resulting from this experiment are also given in this table. Results showed that Lygus spp., Say's stinkbug, and the red-shouldered stinkbug were all capable of drastically reducing the percentage of viable seed produced per plant. None of these insects caused a significant reduction in the yield of seed, nor was the size of the seed affected. Seed produced in the insect cages was, however, slightly lighter in weight than seed produced in check cages.

Examinations of the plants within the cages were made from time to time throughout the duration of the experiment. The plants appeared normal in every respect, and in no case was there any evidence of damage to the plants by the insects.

## Experiment II, 1939

This experiment included the aphid Myzus persicae Sulz. and the false chinch bug (Nysius ericae (Schill.)), which because of their small size were placed in cheesecloth cages. The data resulting from this experiment are given in table 2. These data show that the aphids greatly reduced the yield of seed. The size of the seed was also reduced somewhat, but the germination was apparently unaffected. Infestations within these cages were as heavy as could be maintained without killing the plants. The leaves turned yellow and the whole plant became a sticky mass of honeydew.

Normally several species of ladybird beetles occur numerously in the Salt River Valley beet fields during the fruiting stage of the plants. These beetles and their larvae are predaceous on aphids and have apparently controlled them so far in this area, although some damage to the vegetative stage of the plants in the spring has been noted.

The data in table 2 show that 500 false chinch bugs per plant had no measurable effect on the seed. However, these insects have occasionally been noted to occur in the field so numerously on certain plants as to wilt down the growing tips of the seed stalks. Infestations of this type usually occur in small spots in the fields. In such cases the plants look as though the tips of the seed stalks had been burned. The cage studies, however, indicate that this insect will not cause any material injury to the plants unless it becomes exceedingly numerous, at which time the damage becomes obvious as described.

Table 1.--Yield and quality of sugar beet seed produced in cages containing different insect species, Experiment I, Phoenix, Ariz., 1939

| Species of insect caged | Number of cages | Number adult insects introduced per cage | Average yield of seed per plant | | Average percent small seed balls | Average weight of seed per 100 ml. (grams) | Average percent germinating seed |
|---|---|---|---|---|---|---|---|
| | | | Weight (grams) | Volume (milliliters) | | | |
| Lygus (a mixture of L. hesperus and L. pratensis oblineatus) | 16 | 25 | 57.5 | 320.6 | 13.6 | 18.1 | 32.2 |
| Say's stinkbug (Chlorochroa sayi) | 16 | 10 | 70.6 | 374.8 | 9.5 | 17.7 | 13.4 |
| The red-shouldered stinkbug (Thyanta custator) | 16 | 20 | 70.3 | 409.4 | 11.1 | 17.9 | 32.5 |
| Insect-free (check) | 16 | 0 | 85.9 | 445.2 | 12.3 | 19.7 | 89.3 |
| Difference required for significance | | | 1/ | 1/ | 1/ | 1.2 | 14.1 |

1/ Analysis of the data showed that the differences between the values in these columnns were not great enough to be significant.

Table 2.--Yield and quality of sugar beet seed produced in cages containing different insdct species, Experiment II, Phoenix, Ariz., 1939

| Species of insect caged | Number of cages | Number adult insects introduced per cage | Average yield of seed per plant | | Average percent small seed balls | Average weight of seed per 100 ml. (grams) | Average percent viable (crack test)1/ |
|---|---|---|---|---|---|---|---|
| | | | Weight (grams) | Volume (milliliters) | | | |
| Aphids (*Myzus persicae*) | 16 | No definite number; extremely heavy infestations | 13.5 | 67.3 | 44.4 | 2/ | 63.7 |
| False chinch bugs (*Nysius ericae*) | 16 | 500 | 65.6 | 335.9 | 9.5 | 20.2 | 83.2 |
| Check | 16 | 0 | 66.1 | 338.3 | 8.3 | 20.6 | 82.6 |

1/ In this experiment germination tests were not made, owing to insufficient quantity of seed, therefore only crack-test results are shown. Analysis of the data showed that the differences between these values were not great enough to be significant.

2/ Insufficient quantity of seed for this test.

Experiment III, 1940

As explained in an introductory paragraph, these studies were made with insects caged individually and were for the purpose of determining the comparative damage of the three species of Lygus found to occur in the Southwest as well as the comparative damage of the various forms of Lygus, i. e., females, males, and nymphs. A series of cages containing Say's stinkbug adults were also included in order to compare the damage of this insect with that of Lygus. The results of these tests are given in table 3. The data in the third figure column of table 3 are given in terms of average numbers of nonviable seed balls occurring in each cage, rather than in percentage. This not only gives the comparative damage of the various forms and species of insects, but also gives some idea of the actual number of seed balls one specimen of these various insects is capable of damaging. From these data it will be noted that one adult specimen of Say's stinkbug is capable of damaging nearly twice as many seed balls as any of the Lygus.

In the last column of table 3 are given the average numbers of sprouts per viable ball, and it will be noted that only in case of Say's stinkbug is there a significant reduction in the number of sprouts per viable ball. This means that, in feeding, Lygus do not simply damage one or more of the seeds within the seed ball, but destroy all seeds within the seed ball attacked. Say's stinkbug, on the other hand, in addition to rendering a large number of balls entirely nonviable, may damage one or more seeds within other seed balls without rendering the entire seed ball nonviable.

The total numbers of seed balls produced per cage are also given in table 3. There are no significant reductions in the numbers of seeds produced per cage, and this indicates that none of these insects are responsible for a reduction in the yield of seed, which corroborates the data obtained in Experiment I.

Differences in damage caused by the various forms of Lygus are best shown in table 4, and differences attributable to the various species of Lygus are best shown in table 5. The data in these tables are summarized from those in table 3. Table 4 shows that an equal amount of damage can be expected from females and nymphs of Lygus but that the males cause somewhat less damage than either the females or the nymphs. The fact that the nymphs are responsible for as much damage as the females is important, because at certain seasons of the year the nymphs occur in far greater numbers than do adults. This is particularly true during May, when the seed are the most susceptible to injury by seed-feeding insects. Table 5 shows that Lygus elisus does not cause as much damage as the other two species. As stated in a previous paragraph of this circular, the same species do not predominate in all beet-growing areas of the Southwest, therefore the difference in the amount of damage attributable to the various species becomes of importance in estimating the potential damage of a given Lygus population in a beet field.

Table 3.--Comparison of seed analysis means from individual insect cages, Experiment III, Phoenix, Ariz., 1940

| Species of insect | Number insects per cage | Number cages | Nonviable seed balls per cage | Viable seed balls per cage | Total seed balls per cage | Sprouts per viable ball |
|---|---|---|---|---|---|---|
| Lygus hesperus (female) | 1 | 10 | 96.8 | 344.4 | 441.2 | 1.48 |
| " " (male) | 1 | 10 | 62.8 | 370.3 | 433.1 | 1.53 |
| " " (nymph) | 1 | 10 | 114.4 | 325.1 | 439.5 | 1.46 |
| Lygus p. oblineatus (female) | 1 | 10 | 96.7 | 325.5 | 422.2 | 1.56 |
| " " " (male) | 1 | 10 | 65.1 | 383.8 | 448.9 | 1.58 |
| " " " (nymph) | 1 | 10 | 79.0 | 324.5 | 403.5 | 1.61 |
| Lygus elisus (female) | 1 | 10 | 65.1 | 360.7 | 425.8 | 1.58 |
| " " (male) | 1 | 10 | 54.0 | 355.2 | 409.2 | 1.56 |
| " " (nymph) | 1 | 10 | 65.5 | 365.8 | 431.3 | 1.69 |
| Chlorochroa sayi | 1 | 10 | 206.1 | 126.7 | 332.8 | 1.27 |
| Insect-free (check) | 0 | 10 | 23.4 | 425.1 | 448.5 | 1.62 |
| Difference required for significance | | | 36.0 | ----- | 1/ | .15 |

1/ The differences between the values in this column are not significant by the F test.

Table 4.--Comparison of mean numbers of nonviable seed balls produced in cages containing males, females, and nymphs of Lygus without respect to species

| Form | Number nonviable seed balls per cage | Number viable seed balls per cage |
|---|---|---|
| Female (adult) | 86.2 | 343.5 |
| Male (adult) | 60.6 | 369.8 |
| Nymph | 86.3 | 338.5 |
| Difference required for significance | 15.2 | ----- |

Table 5.--Comparison of mean numbers of nonviable seed balls produced in cages containing various species of Lygus without respect to form

| Species | Number nonviable seed balls per cage | Number viable seed balls per cage |
|---|---|---|
| Lygus hesperus | 91.3 | 346.6 |
| Lygus pratensis oblineatus | 80.3 | 344.6 |
| Lygus elisus | 61.5 | 360.6 |
| Difference required for significance | 15.2 | ----- |

## INSECTICIDE TESTS

Insecticide tests against Lygus spp. were carried on for the first time during 1940 therefore only one season's data are available. As has been stated, Lytgus spp. overwinter in the Salt River Valley largely on weeds and do not migrate to the beets until after seed stalks have developed in April. An approach as a control measure by reducing the insect populations on weeds during the winter or early spring months does not at present seem practical, therefore direct control through the application of insecticides to the beets after the spring migrations have occurred is being tried; and since the damage is largely attributable to the nymphs, because of their predominance in numbers over adults, the application of insecticides was delayed until after the appearance of Lygus nymphs on the beets.

Sixty-four experimental plots of seed beets were devoted to this work. These plots were 23.5 by 32 feet in size, each containing approximately 1/58 of an acre. The plots were arranged in an 8 by 8 Latin square which allowed for the testing of 7 insecticides. The insecticides tested are listed in table 6.

Since sugar beets in the fruiting stage produce such a tall and entangled growth, application of any insecticide to the plants in this stage on a commercial scale could best be made by airplane. On small experimental plots this is not possible, but in order to simulate airplane application on an experimental basis, a movable scaffold was made, and the insecticides were applied with hand equipment from this scaffold. To prevent the intermixing of the insecticides at the time of application, portable barriers 9 feet high were set up around the plot during treatments. These barriers consisted of light wooden frames covered with muslin. Figure 3 shows a plot being treated.

Four insecticide applications were made. The first application was made as soon as nymphs began to appear in the field, which in this case was May 6. Subsequent applications were made at 10-day intervals. Sufficient material was used to give a good cover, and the exact quantity was determined afterward. Some of the dust mixtures flowed through the dusters so much more freely than others that a much greater quantity was applied. This is particularly true of the sulfur and sulfur-paris green mixtures. The quantities of materials used in each case are given in table 6, together with the approximate cost of materials per acre per application. These costs are for small quantities of the materials and could undoubtedly be reduced somewhat if the materials were purchased in large quantities.

All materials caused some reduction in Lygus numbers, although the rotenone and the nicotine sulfate dust mixtures did not show as great reductions as the other materials. The pyrethrum-in-oil spray showed the greatest reduction in Lygus numbers. At harvest time the seed from each plot was harvested separately and samples were analyzed. There were no differences in the weight of the seed produced per plot, but germination tests showed definite differences due to treatment. These data are also

Table 6.--Quantities and approximate cost of insecticides used on experimental plots, and seed-germination data for the various treatments. Phoenix, Ariz., 1940

| Treatment | Average quantity of material used per acre per application | Approximate cost per acre per application | Average percent of germinating seed |
|---|---|---|---|
| Pyrethrum-in-oil spray 1/ (applied with a high-pressure power atomizer) | 22 gals. | $8.80 | 81.3 |
| Paris green and sulfur (1 part paris green and 9 parts sulfur, by weight) | 136 lbs. | 8.70 | 89.3 |
| Ground pyrethrum flowers (0.90% pyrethrins) | 66 lbs. | 29.70 | 89.3 |
| Pyrethrum-extract impregnated dust (0.28% pyrethrins) | 62 lbs. | 13.95 | 92.1 |
| Rotenone dust mixture (1.5% rotenone) | 66 lbs. | 9.90 | 87.4 |
| Nicotine sulfate in lime (4% nicotine sulfate, by weight) | 66 lbs. | 9.24 | 85.6 |
| Dusting sulfur (approximately 325 mesh) | 128 lbs. | 5.12 | 90.2 |
| Untreated check | --- | ---- | 82.5 |
| Difference required for significance | --- | ---- | 3.0 |

1/ 10 parts white oil (viscosity 90-100 sec. Saybolt at 100°F., unsulfonated residue 94 percent), 20 parts kerosene, and 1 part pyrethrum concentrate containing 2.29 percent of pyrethrins.

shown in table 6. From the table it can be seen that the percentage of germinating seed has been increased by the application of insecticides in every case except for the pyrethrum-in-oil spray. Since this material reduced the Lygus populations more than any of the other insecticides, it is probable that the spray damaged the beet flowers. Sulfur gave as good results as any of the other materials tried and is much cheaper.

The increases in seed germination shown in table 6 may or may not be great enough to justify the cost of application on a commercial basis, but from the experimental standpoint they are encouraging. Studies of insect populations in beet fields have shown that Lygus bugs occur in the field, cage studies have shown that these insects cause nonviable seed, and the insecticide tests indicate that control of Lygus will be accompanied by an increase in the percentage of viable seed produced. Populations of Lygus in the experimental field were low, and therefore the percentage of germinating seed from the untreated plots was comparatively high. It is possible that there would have been a greater difference in the percentage of viable seed produced on the treated and untreated plots had Lygus populations been higher. However, much more work is necessary before the problem can be considered solved.

## SUMMARY

Studies of insect populations in fields of sugar beets grown for seed in the Salt River Valley of Arizona have shown that several species of seed-feeding insects infest these fields during the spring months. Of these insects, species of Lygus are the most common, and a direct correlation was found between numbers of Lygus present on the seed stalks during May and the percentage of nonviable seed produced.

Cage studies showed that Lygus spp., Say's stinkbug, and the red-shouldered stinkbug were all capable of reducing the percentage of viable seed produced. These studies also showed that, of the three species of Lygus occurring in the Southwest, L. elisus did less damage than the other two species (L. hesperus and L. pratensis oblineatus). Females and nymphs of all Lygus species were found to cause more damage than males. Say's stinkbug caused more damage per insect than any of the Lygus forms or species.

Field tests of insecticides against Lygus on seed beets indicate that if Lygus can be controlled, an increase in the percentage of viable seed produced will result. Damage to the plants was indicated only in the case of a pyrethrum-in-oil spray. Dusting sulfur gave as good results as any of the materials tried and was by far the cheapest.

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Figure 1.—Field cages used in determining the type of damage attributable to various species of potentially economic insects found to occur in fields of sugar beets grown for seed. The cages were tied around the beet seed stalks at the bottom, and insects were introduced through the top. The cages were set up in the field in randomized blocks with 16 replications. The rectangular screen cages on the left were for other work.

Figure 2.--One of the large screen cages used for the protection of sugar beet plants from field infestations of seed-feeding insects; three such cages were used for this work. The cages were 10 X 15 X 7 feet and were covered with 16-mesh screen wire. The cloth-covered sleeve cages within the large screen cage contained individual specimens of insects being tested to determine the amount of seed damage attributable to various species and forms of seed-feeding insects. One hundred and ten of these sleeve cages were used for this work.

Figure 3.—A dust application being made on the experimental control plots. Insecticides for these experimental tests were applied from a movable scaffold to simulate airplane application. The scaffold was composed of two towers with a foot bridge between and was towed through the field by two automobiles, one hitched to each tower. Portable barriers consisting of cloth-covered frames were placed around the plots during treatment to inhibit the drift of the insecticides from one plot to another.

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